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LOW LATITUDE PC 3 AND PC 4 MICROPULSATIONS

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28 October 1977

Final Report for Period 1 July 1975 - 30 June 1977

Approved for public release; distribution unlimited.

Prepared for

AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
HANSCOM AFB, MASSACHUSETTS 01731

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFGL-TR-77-0294	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) LOW LATITUDE PC 3 AND PC 4 MICROPULSATIONS		5. TYPE OF REPORT & PERIOD COVERED Scientific. Final 1 July 1975-30 June 1977
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Victor L. Badillo		8. CONTRACT OR GRANT NUMBER(s) F19628-76-C-0026
9. PERFORMING ORGANIZATION NAME AND ADDRESS Manila Observatory P. O. Box 1231 Manila, Philippines		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62101F 46430301
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Geophysics Laboratory Hanscom AFB, MA 01731 Contract Monitor: John P. Castelli/PHP		12. REPORT DATE 28 October 1977
		13. NUMBER OF PAGES 9
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Final rept. 1 Jul 75-30 Jun 77,

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

equatorial micropulsations
magnetosphere

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Equatorial Pc 3 and Pc 4 were obtained from normal run magnetogram from January to June 1976 using the eye alone. Micropulsations may possibly be used to derive information on incoming solar particles.

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INTRODUCTION

It is important to make real-time predictions of the energy spectrum and the earth-arrival times of energetic protons emitted from the sun. On the occasion of a solar flare, particles and electromagnetic waves are emitted. Since the waves arrive much earlier than the particles, it is desirable to derive from the electromagnetic waves information on the arrival times and on the energy spectrum of the associated solar protons. Already much important information concerning flare solar protons can be derived from the associated centimeter waves. The review article of Castelli and Guidice (1976) lists and investigates the many solar proton parameters that can be deduced from an analysis of the radio events received over a wide range of several single frequency bands, from the millimeter to the decimeter bands. Some examples are: the probability of a proton event, the magnitude of the predicted proton event, the hardness or softness of the proton energy spectrum, the value of the peak proton flux and the magnitudes of the various ionospheric effects.

Immediately derivable from the received solar microwaves is the radio peak flux density spectrum. The spectral signature of proton events is a U-shaped spectrum with these characteristics: a minimum in the range from 500 to about 2000 MHz, an upper branch where flux increases with frequency and reaches at least 1000 flux units in the 9000 MHz range, and a lower branch where flux increases with decrease of frequency to values above 1000 flux units (Castelli and Barron, 1977). It was shown by Bakshi and Barron (1976) that the slope of the proton peak flux profile could be determined from the ratio f_3/f_2, where f_3 is the frequency of the maximum radio peak flux of the upper branch and f_2 is a calculated frequency corresponding to the lowest frequency in the minimum.

In the upper branch, the radio peak flux does not rise with frequency indefinitely. At some high frequency usually around 10000 MHz (but sometimes as high as 35000 MHz), which varies with the event, the flux begins to decrease. Thus when the sun is observed at frequencies extending considerably beyond 8800 MHz, the value of f_3 can be determined. But this is impossible to do if the sun is not observed at frequencies greater than about 9000 MHz (the limit of many observatories), and if the flux begins to decrease at those unobserved higher frequencies. For this reason it was thought desirable to investigate what proton information could be deduced from the slope of the upper branch. The proton slopes were obtained from Bakshi and Barron (1975) and from Van Hollebeke et al. (1975). The slopes of the peak radio fluxes were derived from the solar radio data of Manila and of Toyokawa. Unfortunately a simple linear relation could not be worked out between the slope of the proton energy and the slope of the upper branch of the U-shaped microwave spectrum. Since a simple linear relation was not apparent, more work is needed to determine what relation does exist.

Also a study was made to determine if the following proton parameters were a function of the position on the visible disk of the associated flare: delay time between flare maximum and proton intensity maximum near earth, slope of proton energy flux, proton energy flux. The data used were obtained from the list of 81 radio bursts of Castelli and Barron (1977) with spectra predictive of proton activity, the list of 25 correlated radio and proton events of Bakshi and Barron (1975), and the tabulated data on proton particles and on H-alpha flares in NOAA's Solar-Geophysical Data. But so far no simple linear relation could be worked out.

EQUATORIAL MICROPULSATIONS

It is desirable to be able to determine the arrival time of solar protons after an associated optical or radio event has been detected. It is becoming clear with recent studies that we have to distinguish several stages in the path of proton particles from their point of emission to the earth: the acceleration and diffusion stage in the solar atmosphere, travel in the interplanetary space, and the travel through the earth's magnetosphere. As a help to some understanding of the last stage, i.e. the travel through the magnetosphere, a study was made of geomagnetic variations near the equator, and particularly of micropulsations.

There is no abundance of papers on experimental data on equatorial micropulsations (Hutton, 1965). This may be due to the scarcity of equipment, since micropulsation data has been obtained either from earth current equipment or from rapid run magnetometers. Furthermore, theoretical understanding is not yet clear (Jacobs, 1970). In making a study of geomagnetic storms occurring in early 1976 it was noted that micropulsations could be detected even in the normal run magnetograms obtained at Davao and Baguio, stations located south and north of Manila respectively. The geographic coordinates in degrees and minutes of these are:

Baguio	16 25 N	120 35 E
Manila	14 38 N	121 05 E
Davao	7 08 N	125 37 E

Micropulsations have been classified according to periods from Pc 1 to Pc 5. But only Pc 3 (10 to 45 seconds period) and Pc 4 (45 to 150 seconds period) micropulsations could be detected in the Baguio and Davao normal run magnetograms. At first a comparator, a magnifier with a reticle, was used to determine the period in a train of micropulsations. The period was determined in two ways: either by dividing the duration of a train by the number of cycles or by measuring directly the time interval between peaks and averaging. But this took too long and induced eyestrain, so another method was used. Since the paper travels two centimeters an hour in the normal run magnetogram and since the eye can resolve one minute of arc, this meant that 0.07 mm on the chart or 13 second fluctuations could be resolved by the unaided eye. Using pulsations whose periods were measured with the comparator, one could develop the skill to pick off Pc 3 and Pc 4 micropulsations. The hours during which micropulsations were seen were noted. The percent occurrence of micropulsations during the period mentioned was done for all days to determine the diurnal variation. But the result was too difficult to analyze. Thus we considered the diurnal variation of Pc 4 for the most-disturbed days during the period and then the diurnal variation during the most-quiet days. This is shown in Figures 1 and 2. The same was done for the Pc 3 micropulsations and can be seen in Figures 3 and 4.

The Pc 4 curve for Davao shows a pronounced maximum at local noon and a secondary maximum at midnight. There is little difference between the disturbed days and the quiet days. At Baguio, farther from the equator, Pc 4 micropulsations are a daytime occurrence on disturbed days but a nighttime occurrence on quiet days. In either case Pc 4 micropulsations occur more frequently at Davao than at Baguio, but the reverse is true for the Pc 3 micropulsations. Pc 3 micropulsations are very frequent in Baguio and show little variation night or day. The Pc 3 micropulsations at Davao are much less during the same period but like those at Baguio show little diurnal variation. These observations are compatible with variations worked out for equatorial and near equatorial stations. But then results from different stations differ and interpretations are not uniform.

Micropulsations can be a sensitive indirect means of determining changes in the state of the upper atmosphere (Jacobs, 1970). Micropulsations are hydromagnetic waves generated by the interaction of solar corpuscular streams with the magnetosphere. The micropulsations can be used to deduce the dimension of the magnetosphere and to derive information about the incoming solar stream of particles.

SUMMARY AND CONCLUSIONS

Pc 3 and Pc 4 micropulsation data at low latitudes during a six month period in 1976 were obtained from normal run magnetograms using the eye alone. The compatibility of the results with earlier results using instruments indicates the possibility of a method for obtaining scarce equatorial data. That micropulsations are generated by the interaction of incoming solar streams of particles with the magnetosphere indicates the possibility of their use to obtain information about the incoming solar particles.

ACKNOWLEDGEMENT

We are very grateful to Mr. John P. Castelli for constantly providing stimulus and encouragement. This research was funded by Air Force Geophysics Laboratory.

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APPENDIX

List of Published Studies

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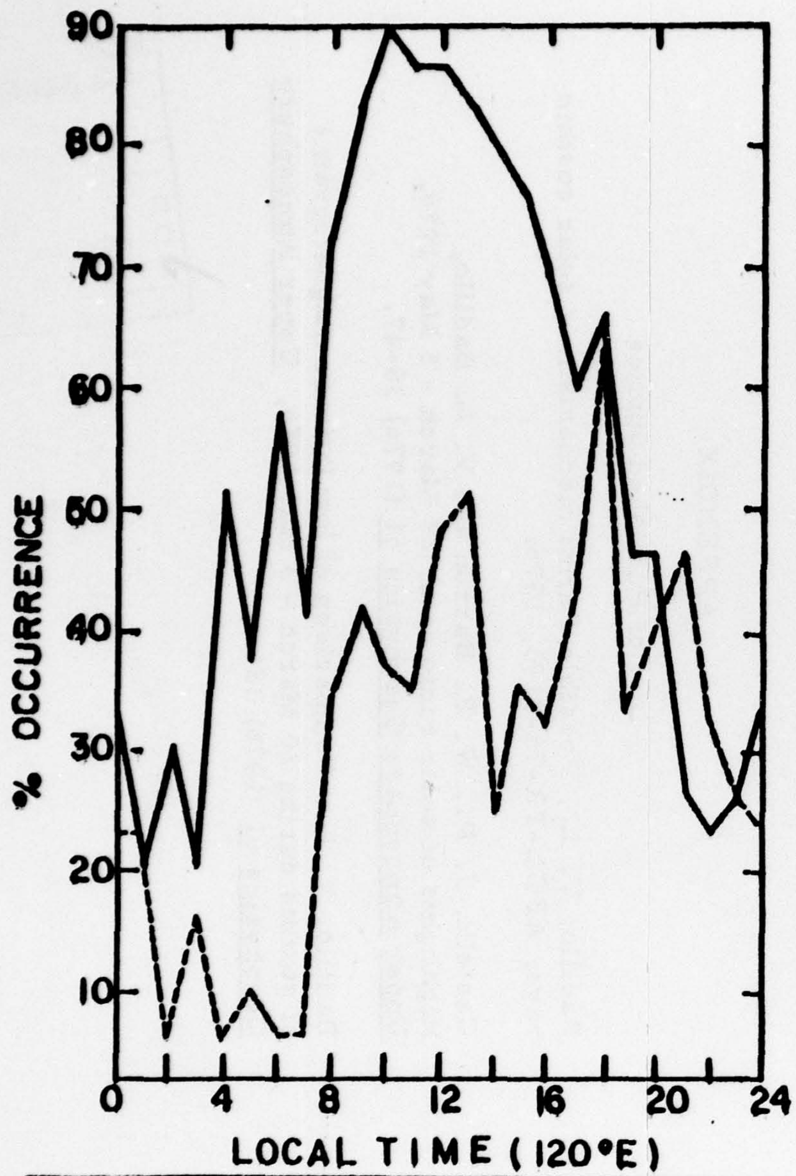

Fig. 1. Diurnal variation of Pc 4 during most-disturbed days observed at Davao (——) and Baguio (- - -).

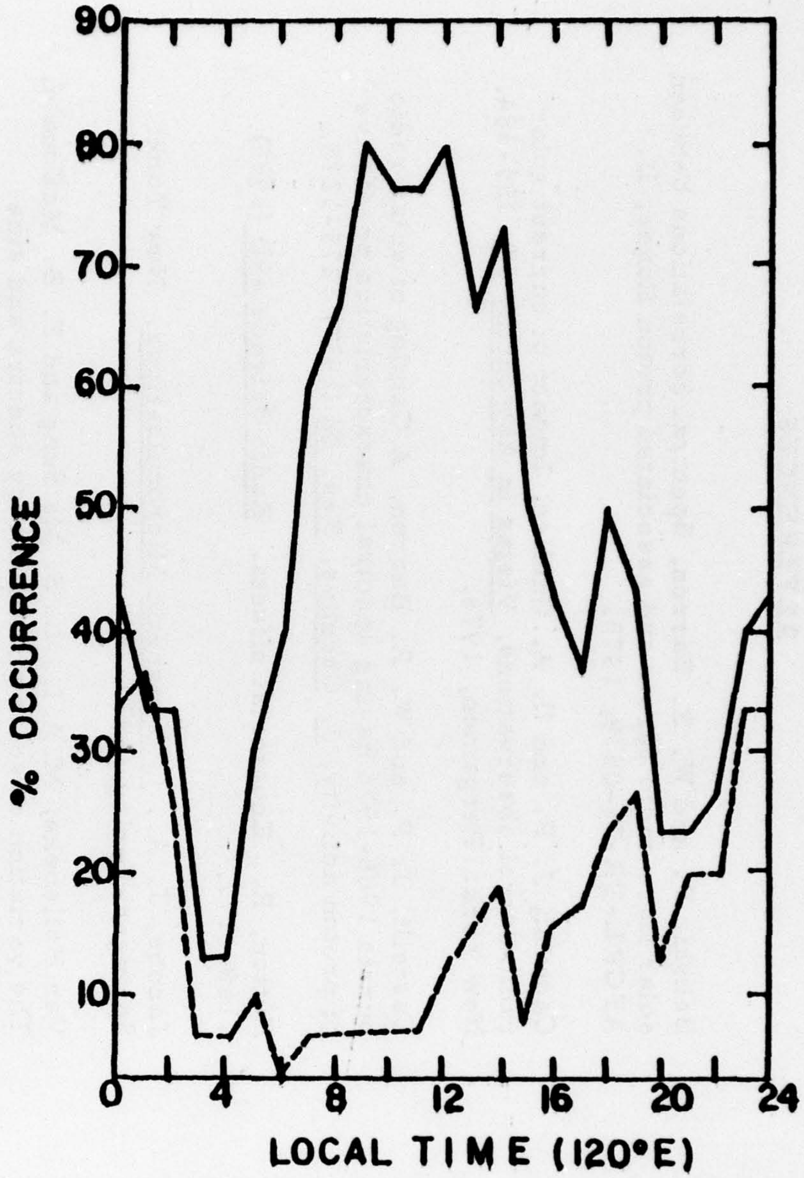

Fig. 2. Diurnal variation of Pc 4 during most-quiet days observed at Davao (——) and Baguio (- - -).

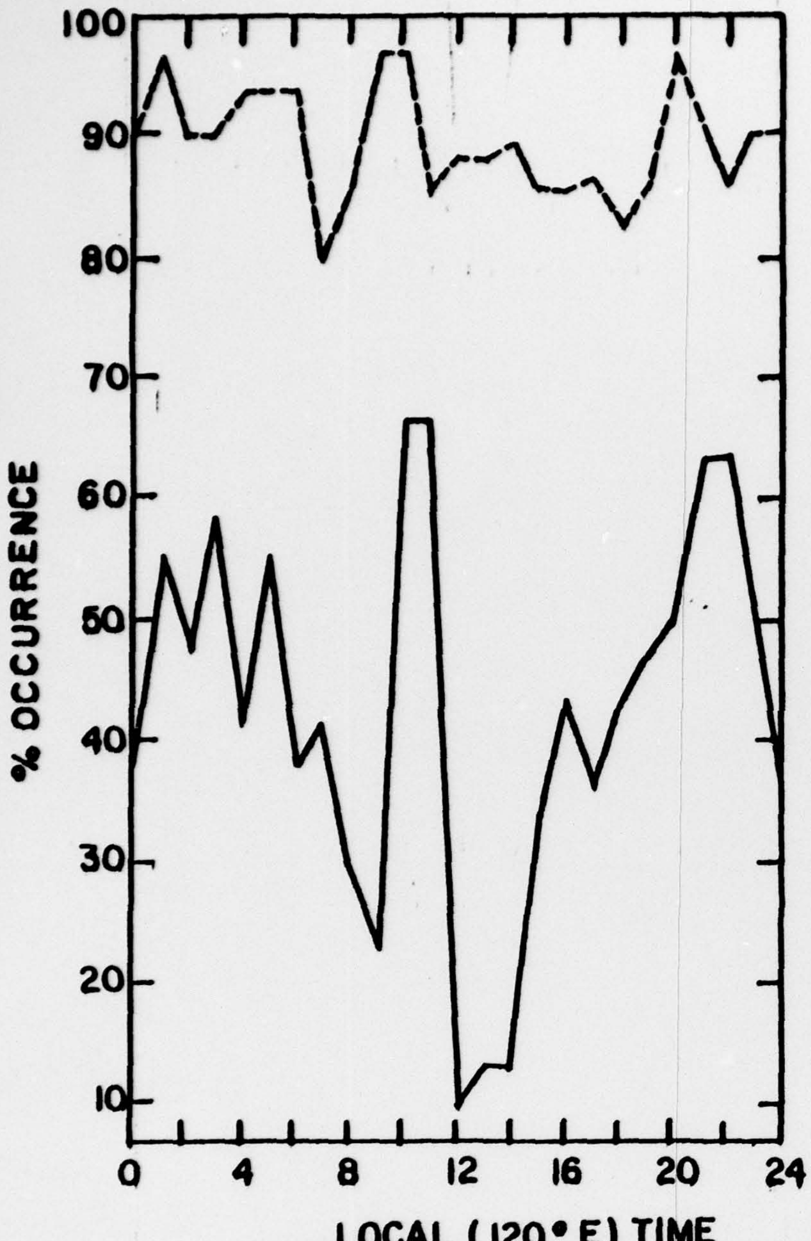

Fig. 3. Diurnal variation of Pc 3 during most-disturbed days observed at Davao (—) and Baguio (---).

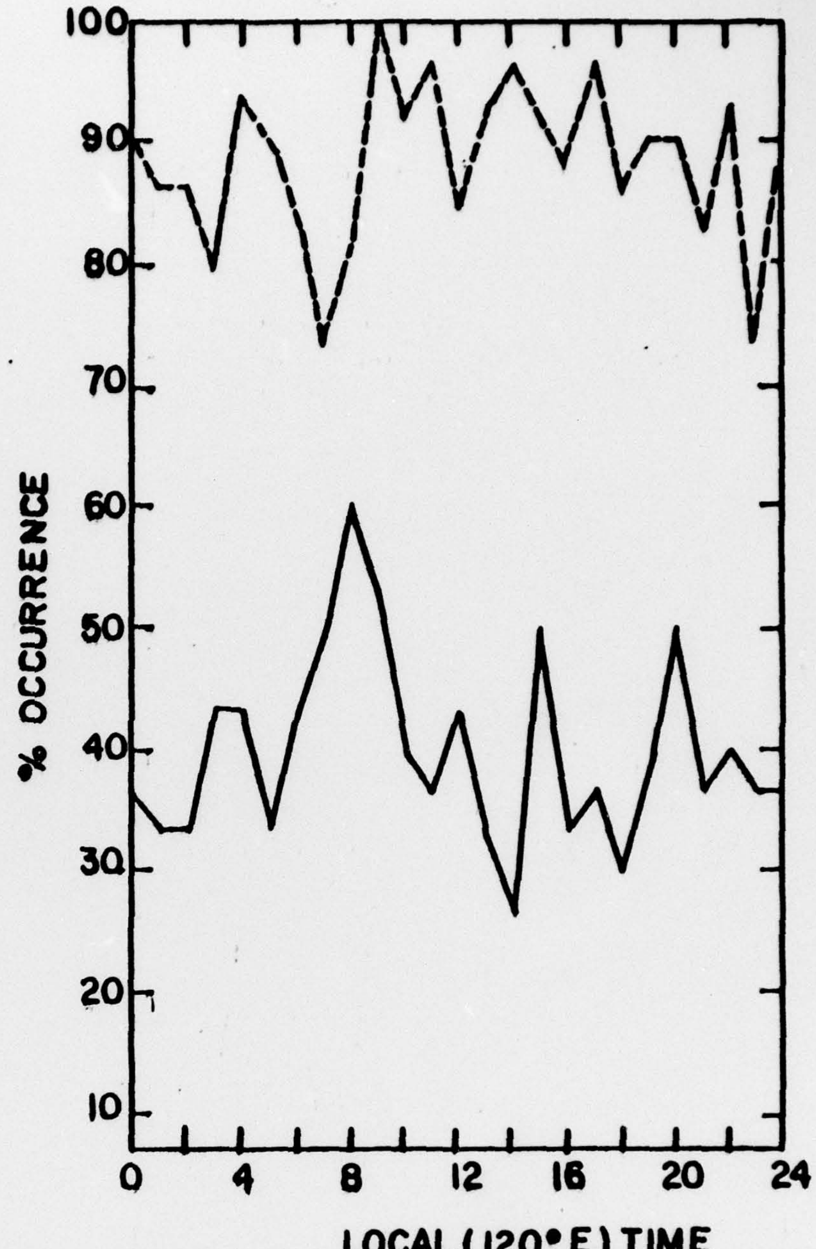

Fig. 4. Diurnal variation of Pc 3 during most-quiet days observed at Davao (—) and Baguio (---).